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Description

A METHOD AND APPARATUS FOR AGGREGATING INCOMING PACKETS INTO OPTICAL BURSTS FOR AN OPTICAL BURST SWITCHED NETWORK

In Optical Burst-Switched networks, or so called OBS networks, packets, e.g. Internet Protocol (IP) packets, Asynchrony Transfer Mode (ATM) cells or protocol data units (PDUs), are aggregated into optical bursts in order to be transferred through the OBS network or respective optical network. The conversion of packets into optical bursts takes place in the edge nodes of an OBS network according to a certain aggregation strategy. The solutions so far provide two main aggregation strategies: the aggregation strategy with timeouts and the aggregation strategy with a buffer limit.

First we will discuss the aggregation strategy with timeouts. A schematic example is shown in Figure 1. In this scheme, packets 102 are added or padded to the burst 104 which is being generated in a buffer 106 until a certain timer T expires. Then the burst 108 is sent.

The second, Aggregation strategy with buffer limit will be discussed with reference to Figure 2. In this scheme, packets 202 are added or padded to the burst 204 which is being generated in a buffer 206 until the buffer is full. Then the burst 208 is sent.

Once the packets are transformed into bursts and sent into the OBS network, they travel in the OBS network through a series of optical switches to a certain destination. At best, these optical switches have limited storage capabilities, e.g. fiber delay lines, and at worst, no storage capabilities at all in the normal case. Therefore, collisions among optical bursts occur. Major performance parameters of an OBS net-

work are thus the burst blocking probability, the throughput and the delay.

The two main aggregation strategies timeout and buffer limit have the disadvantage of a certain blocking probability and maximum achievable throughput.

It is an object of the invention to reduce the blocking probability and increase the throughput of an OBS network.

This object is achieved by the features recited in claim 1, 4 and 8.

The novel inventive aggregation strategy is based on the following widely accepted assumption for highly multiplexed traffic (core networks): the packet arrival rate process is determined according to a Poisson distribution. With this assumption, the idea is to consider the random selection property of any Poisson process, in order to obtain a Poisson process of a lower arrival rate.

This lower-rate Poisson process will mark the beginning of a new optical burst or the end of an optical burst. So it is possible to assure that the burst send and arrival process is Poisson. In addition, the inter-arrival times between bursts will be negative-exponential distributed, as the inter-arrival times of any Poisson process.

It shall be appreciated that advantages of the invention are:

- A lower blocking probability in the optical switches is provided, as compared to the standard aggregation strategies.
- Predictability of the blocking probability. The blocking probability can be calculated with the Erlang-B formula. Whereas for the other aggregation strategies no analytical formula is known.

- Due to the lower blocking probability a higher throughput in optical switches of the OBS network is achieved.
- Predictability of the throughput. The throughput, unlike with the prior art strategies, can be calculated with the help of the Erlang B formula.
- It is easier to calculate waiting times for bursts and/or headers of bursts.
- A lower waiting time for the optical headers in the optical switches.
- In the case burst buffering is available, e.g. by the use of fiber delay lines, a lower waiting time for bursts in the optical switch is achieved.

Further developments of the invention are identified in subclaims.

An exemplary embodiment of the invention is described in greater detail below with reference to a drawing.

Shown in the drawing are:

FIG 1 the initially cited prior art.

FIG 2 the initially cited prior art.

FIG 3 an schematically example for the aggregation and random selection process.

FIG 4 a graph with the blocking probability as a function of the load for different aggregation strategies.

Figure 3 shows two associated timelines P and B. On the first timeline P packets PA, pictured as arrow line, are received in chronological order, e.g. IP packets, ATM cells or PDUs. Every packet is associated with a generated random binary digit. A binary digit has a first and a second value, e.g. 1 for the first value and 0 for the second value or opposite.

So, every packet is associated either with a 1 or a 0. The random binary digits can be generated by a Bernoulli random generator, according to a Bernoulli probability distribution. The probability for every value of the random binary digit, thus the probability (p) for the 1's and (1-p) for the 0's, is determined by a certain probability distribution, e.g. p(1)=0,01 and p(0)=0,99. These packets are aggregated in a buffer to accumulate an optical burst. A packet with an associated first value, e.g. with a 1 indicates a transition between optical bursts, e.g. the beginning of a new burst. In figure 3 this is labeled with BA. The chronological last packet with a 0 before a packet with a 1, is the last packet of the burst, marked with LPB in figure 3. On the second timeline B in figure 3 the resulting Bursts B1, B2 and B3 are shown. The time difference Z between the beginning of two successive bursts is called inter-arrival time. The aggregation delay is the delay experienced by a packet in the edge node until the burst to which it belongs is completed. After appearance of a packet with a 1, a new burst begins and the old burst is send into the OBS network.

The used probability distribution determines the average number of packets per burst. E.g. the average number of packets per burst is equal to 1/p(1). For the example, if p(1)=0,01, the average number of packets per burst is 1/p(1)=100 packets per burst.

The method can also be realized, that the second value indicates a transition between optical bursts.

Also the first value indicates, instead of the beginning of a new burst, the end of the aggregated packets and by that the end of the aggregated burst.. The main idea is, that a generated random digit with a certain probability indicates the beginning or the end of a burst, which consists of aggregated packets, e.g. IP packets.

The invention can be implemented by the following steps/algorithm:

- Every time the edge node receives a packet, e.g. an IP packet, it sends it to the buffer.
- Then the edge node reads the generated associated random binary digit / random number corresponding to the next packet.
- If the associated random binary digit / random number for the next packet is a first value, e.g. a 1, the accumulated burst in the buffer is sent.
- Otherwise, do nothing.

A simulation has been done with Matlab® in order to calculate the blocking probability in an optical switch with no wavelength conversion available as a function of the load.. The results are presented in figure 4. In figure 4 AT means aggregation strategy with aggregation timer, AB means aggregation strategy with aggregation buffer, Erl B means theoretically possible load according to Erlang B formula and RS means inventive aggregation strategy with random selection.

It can be observed that the inventive random selection strategy leads to the lowest blocking probability and furthermore it matches the Erlang-B formula predictions.